ANALYSIS OF ARMY TRANSFORMATION AND THE EFFECTS ON CUSTOMER ORDERING BEHAVIOR

THESIS

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Abstract

The United States Army began a major force transformation in 2003, which required a significant shift in logistics support constructs. This thesis provides an in-process review of the effects of the current transformation efforts on supply effectiveness and attempts to determine factors that influence customer ordering behavior. Specifically, this thesis sought to answer three subproblems addressing the effect of transformation on supply effectiveness, the correlation of supply effectiveness metrics to customer ordering behavior, and identify other potential sources of variance in ordering behavior.

The subproblems were answered through an examination of the supply document histories of two Brigade Combat Teams during two six month periods, one in garrison and one in Iraq. The results indicate that force transformation is increasing overall supply effectiveness, but that there is no correlation between the variables of supply effectiveness and customer ordering behavior.

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Joseph M. Colacicco

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ANALYSIS OF ARMY TRANSFORMATION AND THE EFFECTS ON CUSTOMER ORDERING CHARACTERISTICS

I. Introduction

Background

The United States Army began force transformation after Desert Storm/Desert Shield with what was originally known as the Revolution in Military Affairs (Maccagnan, 2005:1). The purpose was to develop the Cold War force structure into a more responsive and agile force capable of handling a wide spectrum of operational scenarios (Caldera and Shinseki, 2000:3). A responsive and agile force requires a responsive and agile logistics structure.

The Army logistics community took major initiatives in the mid-1990's to reduce stockpiles at the tail-end of the supply pipeline and compensate with increased velocity of shipments. This was known as Velocity Management and has evolved into the current doctrine of Distribution Based Logistics (DBL). The 1998 shift to Velocity Management yielded one major problem that was to be recognized in the major force deployments to Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF): the logistics community had focused on the reduction of stockage levels without a simultaneous improvement in the distribution network, resulting in low supply levels and no way to efficiently deliver more (ADCS-G4, 2003:6).

The current Army transformation is from a Division and Corps based structure to a modular force structure using the Brigade Combat Team (BCT) as the primary level of operations. These structures are more deployable and capable of a wider spectrum of missions with only their internal assets. This type of unit requires a matching change in the logistics doctrine. The current draft doctrine consolidates support assets in the BCTs, creates a robust Sustainment Brigade at the Division level, eliminates the Corps Support Command, and creates modular Theater Sustainment Brigades (CASCOM, 2004:6). The question that remains is: Are the revised logistical concepts having an impact at the BCT level?

Without an in-process analysis of the effects of the current changes, it is possible that the desired improvements and move to DBL will not be realized. For Distribution Based Logistics to successfully function, the flow of supplies through the entire supply chain must be smooth, rapid and lacking in variance. Common knowledge in both the civilian and military logistics communities states that the absence of these traits leads to large orders, misallocation of priority levels for requests, and an overall mistrust in the supply system. This mistrust only increases the belief that orders need to be padded and that only high priority level requests are filled. The goal of logistics transformation needs to be reduced and steady Customer Wait Time (CWT) in order for the DBL concepts to properly operate; with CWT being the amount of time that passes between customer request and receipt.

Problem Statement

Logisticians need to know if the current changes in the force structure and logistics processes are having a positive effect on overall distribution effectiveness. This

research attempted to answer this question through determining the effect of Army transformation on supply effectiveness for BCT level units and attempting to identify the effects of the supply effectiveness on customer ordering behavior in terms of the overuse of high priority designators and average order quantities. Three subproblems served to answer the research problem.

Subproblems and Hypotheses

Subproblem 1

The first subproblem was to determine the effects of Army transformation on supply effectiveness using the supply chain metrics of CWT and requisition backorders at the Brigade Forward Distribution Point (FDP) for units that have completed transformation. This subproblem was addressed with Hypothesis 1 (H1):

H1: Transformation status is positively correlated to supply effectiveness; using an inference from the two following quantitative hypotheses.

H1a: Transformed units will have a lower average CWT for requisitions.

H1b: Transformed units will have a lower average quantity of requisition backorders at their supporting FDP.

Subproblem 2

The second subproblem was to establish the correlation of the supply effectiveness indicators of requisition backorders and CWT to the ordering characteristics of average order quantity and requisition priority designators. Hypothesis 2 (H2) defined the correlations.

H2: Ordering behavior is positively correlated to supply effectiveness; based on a combined inference from the following four quantitative hypotheses.

H2a: The average customer order quantity is positively correlated to the quantity of requisition backorders at their supporting warehouse.

H2b: The percentage of high priority designators (PD 02) assigned to requisitions is positively correlated to the quantity of requisition backorders at the customer's supporting warehouse.

H2c: The average customer order quantity is positively correlated to CWT.

H2d: The percentage of high priority designators (PD 02) assigned to requisitions is positively correlated to CWT.

Subproblem 3

The third subproblem was to account for other sources of variance in the results. This subproblem utilized two hypotheses to serve as filters for ordering behavior.

H3: Units submit a higher number of requisitions when deployed.

H4: The allocation of priority designators is proportional to the number of customer requisitions.

Research Objectives and Significance

The objectives of this research were twofold. The first objective was to provide an answer concerning the impacts of force and logistics transformation on Customer Wait Time and requisition backorders for modular units. The second objective was to determine if there is a correlation between the aforementioned metrics and customer ordering behavior, specifically priority assignments and order quantities. In the review of the literature, no previous studies on the effects of the current transformation, as well as no definitive analysis of the effects of supply chain performance on customer ordering characteristics were discovered. This lack of published analysis makes quantifying

improvements difficult at best. This research provides actual analysis of customer requisitions at the BCT level in an attempt to define the widely held beliefs concerning CWT and backorders respective effects on customer behavior.

Research Scope and Limitations

This research evaluated the subproblems through analyzing the Class II (General Supply) and Class IX (Repair Parts) requisitions for two Brigades, one transformed Brigade and one legacy Brigade, during two six-month periods, one in garrison and one in Iraq. Some of the major limitations were the long-term nature of the transformation process, meaning that not all levels of the supply chain have not transformed; difficulty in normalizing unit ordering behavior due to operational differences in the force structure; and differences in the ordering systems and characteristics of the different supply classes. These limitations and the respective delimitations are discussed in Chapter 3.

II. Review of the Related Literature

This chapter presents the background information required to understand Army logistics transformation and the importance of the hypotheses chosen for evaluating the research problem. In order to do this, one must first understand the definition of transformation in the sense of the current changes in the U.S. Army. The definitions are followed by a discussion of the basis for operational force transformation, logistics transformation, and logistics doctrine development. The chapter closes with a look at new metrics for evaluating the supply chain and the influence of Customer Wait Time on customer ordering behavior.

Defining Transformation

Transformation is a broad and ambiguous word that can apply to any process change. In terms of the current U.S. Army reorganization, transformation is defined as "a process that shapes the changing nature of military competition and cooperation through new combinations of concepts, capabilities, people, and organizations" (Department of the Army, 2003b: D-3). This seemingly ambiguous definition reflects the breadth of change currently occurring in the U.S. Army. The most basic change is the transformation from a Cold War force focused on fighting on a widespread linear battlefield to an Army based on a modular force concept. These are new organizations designed to "provide a mix of land combat power that can be task organized for any combination of . . . operations in support of a joint campaign" (TRADOC, 2003:1-6). There are three primary levels of modular forces: Brigade Combat Team (BCT), Primary

War fighting Headquarters (UEx), and the Joint Support Headquarters (UEy) (TRADOC, 2003:1-7).

Basis for Transformation

Understanding of the goals of transformation is critical to being able to evaluate the current direction of logistics change. This discussion provides an overview of Army transformation and logistics transformation.

Operational Force Transformation

The Army is transforming from its Cold War force structure based on forward deployed units into a more responsive and agile force. The process began after Desert Storm/Desert Shield with what was initially described as the Revolution in Military Affairs, now known as transformation (Maccagnan, 2005:1). It was determined that the land forces needed the capability to respond to a variety of missions, including humanitarian assistance, disaster relief, peace-keeping, peace-making, and major theater wars (Caldera and Shinseki, 2000:3). In fact, since 1995, the U.S. Army has participated in all of the above operations from Haiti to Bosnia and Afghanistan to Iraq. The determination was made that the new force structure must be responsive, deployable, agile, versatile, lethal, survivable, and sustainable (Caldera and Shinseki, 2000:4-5).

Logistics Transformation

Logistics transformation is requisite in meeting all of these characteristics, with its greatest presence in deployability, agility, and sustainability. In order to meet the deployability goals of a Brigade Combat Team (BCT) on ground anywhere in the world in 96-hours, Division level units (3-4 BCTs) in 120 hours, and five Division equivalents in 30 days the logistics footprint must be minimized (Peltz, Halliday, and Hartman,

2006:6). Agility requires that a BCT be able to transition missions quickly and move rapidly across the battle-space, which means its internal support needs to be capable of self-movement, without external support for short durations (less than 72 hours) (CASCOM, 2004:4). Finally, the force must be sustainable, with minimal internal logistics. Every increase in internal logistics capability creates a subsequent increase in the assets required to move the force. This fact has created the move to Distribution Based Logistics for the entire Army supply chain, an operational concept relying on "distribution velocity and precision, rather than redundant supply mass, to provide responsive support" (McKay and Flowers, 2000, 44).

Development of Logistics Doctrine

As the Army transforms, a new support doctrine is required. The difficulty in developing new support structures is that the requirements are not fully realized until the combat force is transformed. As the Army moves from the Corps to the Brigade Combat Team as the level of employment, logistics forces are required to modularize and rely on Distribution Based Logistics (Hilburn, 2006:16).

The basic concepts for the logistics transformation to DBL were outlined by the Army Deputy Chief of Staff-G4, LTG Christianson, in 2003. He described the four focus areas required to meet the critical task to "sustain the combat readiness of our Deployed Force and to maintain the operational readiness of the Current Force" (ADCS-G4, 2003:2). The areas are: connect Army logisticians, modernize theater distribution, improve force reception, and integrate the supply chain.

Modernizing theater distribution "rests solidly on the fundamental concepts of distribution-based logistics" (ADCS-G4, 2003:4). Distribution improvement reduces the

variance in lead times and enables the reduction of forward stocks required to maintain the force. Improved distribution will allow the integration of the components of the supply system into one large storage chain, with stocks stored in CONUS and in the pipeline, instead of stored forward, which is a recognition of the problem created by the 1998 shift to velocity management under the Revolution in Military Logistics (Maccagnan, 2005:2). The problem was the large-scale reduction of stockage levels in units without a simultaneous improvement in the distribution network, resulting in low supplies and no way to efficiently deliver more (ADCS-G4, 2003:6).

The U.S. Army Combined Arms Support Command (CASCOM) has developed draft doctrine for logistics transformation. This doctrine consolidates support assets in the BCTs, creates a robust Sustainment Brigade at the Division level, eliminates the Corps Support Command, and creates modular Theater Sustainment Brigades (CASCOM, 2004:6). The elimination of a level of logistics headquarters is an obvious improvement; removing layers is an accepted way of improving processes in business, so it will work in military logistics through helping to reduce the "Bullwhip Effect." The consolidation of support assets in the Brigade Combat Teams is another major change. These assets will fall under the Brigade Support Battalion (BSB), which will provide full support for the maneuver battalions assigned to the BCT. An enhancement to the BSB is the Materiel Management Center (MMC), an asset that was previously located only at the Division level. The MMC is the supply ordering and maintenance control section for the BCT; this organization is the true enabler for a BCT to be able to move under any other headquarters.

These changes in the logistics force facilitate the movement of supplies through the distribution pipeline. Fewer headquarters layers lead to shorter time for the requests to reach the Inventory Managers from overseas with less information distortion. The placement of an MMC in every BCT enables the tracking of incoming supplies and outbound requests to be managed at the level that needs the information. With these changes to the logistics doctrine and force structure come an intuitive change in the metrics that are used to measure the effectiveness of the supply chain. The metrics must reflect the intent of the system that they are measuring.

Choosing the Metrics

To evaluate any system, mutually agreed upon metrics must be developed. The old supply metrics, such as the number of zero balance lines at the tactical Supply Support Activity, are exchanged for the stockage level in the pipeline. The old order ship-time standards are no longer relevant for supporting units that maintain less than 72-hours of on-hand supplies. If a request takes 14 days to arrive, there is no way to carry only 72-hours of on-hand stock and survive until the order arrives. Order ship-time is not an obsolete metric; it is still useful for measuring the inter-process time for shipments between supply levels.

Reduction of forward assets mandates the rapid delivery and elimination of variability in the supply chain (ADCS-G4, 2003:6). Measurement of the effectiveness of these improvements is most accurately reflected by Customer Wait Time (CWT), which became an official metric in 2001 for use in evaluating velocity management improvements. CWT "measures the speed and efficiency of the logistics community's ability to support the soldier in the field" (Department of the Army, 2003a:1-12). The

metric encompasses the entire span of time from when a unit enters a supply request until the unit has the item in hand. As an end-to-end measure of the supply chain, CWT is a better measure of a logistics structure reliant on distribution and can serve as a predictor of customer ordering behavior. For this reason, CWT is the metric that used in this research to evaluate overall improvement of the supply chain and its effects on customer ordering behavior.

The Influence of Customer Wait Time on Customer Ordering Behavior

Based on the change to Distribution Based Logistics, the measurement of interest becomes Customer Wait Time (CWT). CWT is a reflection on the change in the logistics community to a focus on customer support. This is the lead time for resupply that customers of the supply system use for planning. If CWT variance is high, which results from inefficiencies and breakdowns in the distribution system, the current belief is customers will pad orders to cover future lead times (Myers, 2004). If CWT is extremely high, the current belief is units will use a higher quantity of high-level priority designators for requisitions in order to fill critical shortages or due to impatience with the system (Myers, 2004). In 2003, for all OIF requisitions, 80% of Class II and over 50% of Class IX requisitions had priority designators of 1, 2, or 3, which are all from the top tier of requisition priority levels (Carpenter, 2004:22). The result was that all of the high priority requests became average priority, which further exacerbated the problem and diluted the resources available for moving true high priority shipments.

Summary

The Army is in the process of transforming from its Cold War structure to a modular force structure based on the need to accomplish a wide variety of missions with a new set of performance characteristics. To meet the goals of the new force structure, a corresponding change in the logistics force is required along with a new logistics doctrine. To provide responsive and flexible logistics support, Army logistics is moving from a just in case stockage mentality to a distribution based support structure. The change to a distribution based structure requires a different metric to be used for measuring the effectiveness of the system. In this thesis, Customer Wait Time was the metric used to evaluate the effectiveness of the changes in the support structure for the modular Army.

III. Methodology

The purpose of this chapter is to outline the methodology used in conducting the research. The first topic is the limitations and delimitations, followed by sample selection. The next topics are data requirements and data collection. The chapter will conclude with a discussion of the treatments of the data to answer the hypotheses discussed in Chapter 1.

Limitations and Delimitations

This research faced several limitations based on the large scale and long-term nature of the Army transformation process. The first limitation was that all of the layers of the supply chain have not undergone transformation; rather, transformation is occurring in a patchwork fashion across the force. This prevented a full analysis of the effectiveness of the reformed supply chain. The delimitation was to only focus on the BCT level for analysis and use CWT as the metric for measurement. CWT accounts for the entire supply chain, therefore above BCT changes were applied equally to both Brigades. The potential difference in CWT was limited to transformation status.

The second limitation was the difficulty in normalizing unit ordering behavior due to operational and structural differences in the force structure. The operational delimitation was to evaluate both Brigades in garrison and in Iraq, which encompassed a larger spectrum of time and situations in order to make a better comparison. The structural delimitation was to normalize the two sample Brigades. Due to a modular Brigade having units with traditionally low density or limited part availability equipment, Engineers and Field Artillery, these units were excluded from the evaluation. The only

assigned units analyzed were the maneuver battalions and support battalion. This ensured that the results are not skewed by requisitions for parts that traditionally have long wait times.

The third limitation was the rapid changes in the overall logistics structure as Operation Iraqi Freedom progressed. The shortages of 2003 are well documented and other fluctuations could potentially skew the data. The delimitation was to look at the two Brigades during the same six-month periods. This ensures that both were subject to the same logistical fluctuations.

The fourth limitation was that different supply classes have widely varying ordering systems and characteristics. The delimitation was to focus on only Class II (General Supply) and Class IX (Repair Parts) requisitions. These two classes exhibit similar ordering characteristics and are both stocked at the same warehouses at the BCT level.

Sample Selection

Based on the above limitations, the research required two Brigades that were in garrison and Iraq during the same periods, one transformed and one legacy. The Brigades were chosen through analyzing Division websites and news releases until two that most closely met the criteria were selected. Hereafter, the legacy Brigade is referred to as Unit 1 and the transformed Brigade as Unit 2. As previously discussed, the units inherent to a transformed Brigade that are not part of a legacy Brigade were excluded from the analysis. Specifically excluded were the Engineers, Field Artillery, and Special Troops Battalion. The periods used for Unit 1 are 1 June – 30 November 2005 (Garrison) and 1 June – 30 November 2006 (OIF). For Unit 2, the periods are 1 May – 31 October

2005 (Garrison) and 1 May – 31 October 2006 (OIF). The off-set was due to deployment sequencing and to ensure that the periods used did not include dead time due to deployment/redeployment.

Data Requirements

Determining the effect of Army transformation on supply effectiveness at the BCT level and identifying the respective effects on customer ordering characteristics required establishing correlations between the variables using a longitudinal data set. In order to address CWT, priority assignment, and average order quantities, the data requirements were all of the requisitions and issues posted by the units of interest during the periods of evaluation. The requisition backorder analysis required the respective warehouse backorder statistics during the periods of interest. Collecting the data first required obtaining the Department of Defense Activity Address Codes (DODAAC) for all of the sample units and the Routing Identification Codes (RIC) for the warehouses.

Data Collection

All of the data requirements were met through the Army Logistics Information Warehouse (LIW), an on-line repository of all logistics related data for the U.S. Army. The first step was to obtain the required DODAACs and RICs for the units of interest. These were retrieved from the Logistics Information Database (LIDB), accessed through LIW. For each company level unit, the Class II and IX DODAACs, both for garrison and Iraq were retrieved. Table 1 shows the results. The difference in the number of DODAACs is due to transformed units having an additional maneuver battalion and additional companies in the support battalion. The next step was to retrieve the RICs for

Table 1. Number of DODAACs by Unit and Type

	Unit 1		Unit 2	
	II	IX	II	IX
Garrison	15	17	26	32
Iraq	16	19	25	29

Source: Army Logistics Information Database

the warehouses, also using LIDB; this provided 2 RICs for each BCT, one each for garrison and Iraq.

The documents were retrieved through the Integrated Logistics Analysis Program (ILAP), also accessed through LIW. The entire document history for each DODAAC was downloaded by utilizing the SARSS 2B Document History (DIC-NIIN) report function. The backorder data for the warehouses was retrieved through the SARSS Backorder Report Module. The backorder data was compiled in approximately week increments, these same increments were later used to organize the requisition and issue data for analysis. The time increments produced in this report were used as the periods of analysis for all of the testing in this thesis. A full listing of the periods is provided in Appendix A, Table 7.

Total data retrieved for conducting the analysis included 154,842 customer issues for CWT calculations, 149,699 requests for priority designator and order quantity calculations, and Classes II and IX backorder data for 94 periods to conduct backorder calculations.

Treatment of the Data

This section discusses the treatment of the data as it pertains to preparing to answer the hypotheses associated with the three subproblems. Table 7 in Appendix A

shows the periods used for analysis and Table 8 in Appendix A provide a sample data table for the reader's reference.

Hypothesis 1

Recall that H1 proposed that transformation status is positively correlated to supply effectiveness. CWT and average quantity of requisitions backorders served as proxy variables for supply effectiveness. This study measured CWT as the amount of time from the Julian date of the requisition document number to the time the customer issue was posted by the warehouse. Comparing the two BCTs was accomplished using a series of two-sample T-tests for each of the variables; these test were then used to infer the answer to the first hypothesis.

The CWT comparisons were conducted by calculating the average customer wait time for each period as provided by the above mentioned backorder report. The comparison samples consisted of the average of all periods for that unit. For example, the garrison Class II requisitions average for Unit 1 was calculated using 23 periods. Each period consisted of the average among the combined requisitions from each of the 15 DODAACs. The average quantity of requisition backorders comparisons were conducted by comparing the average of the backorders older than 30 days at the BCT warehouse. Thirty days was used because it is the generally accepted point at which customers begin to look at alternate ordering means.

Hypothesis 2

H2 proposed that customer ordering behavior is correlated to supply effectiveness. This hypothesis utilized average customer order quantity and percentage of the total requisitions that are high priority (PD 02) as proxy variables for ordering

behavior and average requisition backorders and CWT as proxies for supply effectiveness. The data results were calculated utilizing a Pearson Correlation Matrix with the variables compared across each period. Average customer order quantity was calculated by taking the average quantity for all of the items ordered during a period by the unit for a specific class of supply. One important note is that the customer ordering characteristics used for the analysis were lagged one period behind the supply effectiveness characteristics.

Hypothesis 3

H3 proposed that the customers will submit more requisitions while deployed. This hypothesis was analyzed using a t-test to compare the number of requisitions between deployed and garrison units. The data consisted of the average of all 192 order periods for both units in garrison and both units in Iraq. The correlations were calculated based on all orders, not separated by Class II and IX.

Hypothesis 4

H4 proposed that the allocation of priority designators is proportional to the number of customer requisitions. This hypothesis was analyzed using a Pearson Correlation Table for the variables of percentage of high priority (PD 02), percentage of medium priority (PD 05), percentage of low priority (PD 12), and Total Number of Requisitions compared across the periods. Further analysis was conducted using a t-test to compare the average percentage of PD 02 requisitions for garrison and Iraq.

IV. Results and Analysis

This chapter provides the results of each hypothesis test and answers the subproblems. It is organized in order of each subproblem with their respective hypotheses.

Subproblem 1

The first subproblem was to determine the effects of Army transformation on supply effectiveness using the supply chain metrics of CWT and requisition backorders at the Brigade Forward Distribution Point (FDP) for units that have completed transformation. Hypothesis 1 proposed that transformation status is positively correlated to supply effectiveness.

H1a Results

This portion of H1 stated that transformed units will have a lower average CWT for requisitions. Five different t-tests were conducted: between both units for all supply in garrison, between both units for all supply in Iraq, between both units for Class II in both locations, between both units for Class IX in both locations, and for both units for all supply in both locations. The N represents the number of periods used in the analysis as discussed in Chapter 3.

Two of the tests reported no significant difference at a 95% confidence level; these were Class IX in both locations ($p = 0.0640$) and both supply classes in Iraq ($p = 0.1220$). Overall the results show there was a significant improvement in CWT with the transformed BCT (Unit 2) with an estimated difference of 7.94 days. Even more

interesting is that in every test, the standard deviation was significantly less for Unit 2. Table 2 shows the full set of results.

Table 2. Results for Customer Wait Time Comparisons

Test #	Unit/Location	Supply Class	N	Mean	Std Dev	SE Mean	Difference Estimate	95% CI for Difference Lower	95% CI for Difference Upper	Significance Level*
1	Unit 1 Garrison	II/IX	46	33.2	15.8	2.3	10.8	5.06	16.54	0.0000
	Unit 2 Garrison	II/IX	38	22.4	10.5	1.7				
2	Unit 1 Iraq	II/IX	54	32.3	20.5	2.8	5.85	-0.34	12.03	0.0640
	Unit 2 Iraq	II/IX	54	26.45	9.98	1.4				
3	Unit 1 All	II	50	44.3	16	2.3	12.84	7.47	18.2	0.0000
	Unit 2 All	II	46	31.42	9.89	1.5				
4	Unit 1 All	IX	50	21.2	12.5	1.8	3.038	-0.83	6.91	0.1220
	Unit 2 All	IX	46	18.17	5.33	0.79				
5	Unit 1 All	II/IX	100	32.7	18.4	1.8	7.94	3.72	12.15	0.0000
	Unit 2 All	II/IX	92	24.8	10.3	1.1				

* Result is significant if ≤0.05

H1b Results

This portion of H1 proposed that transformed units will have a lower average quantity of requisition backorders at their supporting FDP. Six different t-tests were conducted: between both units for Class IX in garrison and Iraq, between both units for Class IX in garrison, between both units for Class IX in Iraq, between both units for Class II in garrison and Iraq, between both units for Class II in garrison, and between both units for Class II in Iraq. The reason for only looking at separate backorder levels was that there is a difference in urgency between Class II (General Supply) and Class IX (Repair Part) requisitions. In this respect, these two classes are different in their effects on ordering.

The results show that Unit 2 had a higher average number of backorders over 30 days than Unit 1 in all areas except for garrison requisitions. In garrison, Unit 2 had fewer average backorders than Unit 1 for both Class II and Class IX. The full results are presented in Table 3.

Table 3. Results for Average Backorder Comparisons

Test #	Unit/Location	Supply Class	N	Mean	Std Dev	SE Mean	Difference Estimate	95% CI for Difference Lower	95% CI for Difference Upper	Significance Level*
1	Unit 1 All	IX	48	2113	489	71				
	Unit 2 All	IX	46	2906	1307	193	-792.96	-1204.11	-381.81	0.0000
2	Unit 1 Garrison	IX	22	2098	177	38				
	Unit 2 Garrison	IX	19	1674	472	108	423.77	185.79	661.74	0.0010
3	Unit 1 Iraq	IX	26	2125	651	128				
	Unit 2 Iraq	IX	27	3772	956	184	-1647.12	-2098.31	-1195.93	0.0000
4	Unit 1 All	II	48	775	321	46				
	Unit 2 All	II	46	1145	725	107	-370.64	-603.58	-137.71	0.0020
5	Unit 1 Garrison	II	22	492	114	24				
	Unit 2 Garrison	II	19	420.4	95.5	22	71.9	5.54	138.26	0.0340
6	Unit 1 Iraq	II	26	1014	230	45				
	Unit 2 Iraq	II	27	1656	499	96	-641.82	-856.98	-426.67	0.0000

* Result is significant if ≤0.05

Results and Analysis of Hypothesis 1

Based on the two subparts, transformation status is not positively correlated to supply effectiveness. Transformation is associated with improved CWT, but the number of backorders increased. The full answer depends on one's world view of backorders and CWT. If the backordered items were lower demand or PD 12 requisitions then it is not a negative result. If the items were PD 02 requisitions, then it is a negative result. This researcher's view is that CWT and its variance are more important than the overall number of backordered requisitions in determining supply effectiveness, particularly if it does not result in higher order quantities or duplicate orders at a higher priority level.

To verify this, a Pearson Correlation calculation was calculated for the effects of backorders over 30 days on average order quantity and percent PD 02 requisitions for Unit 2, which yielded statistically insignificant correlations of -0.014 and -0.047 respectively. This shows that there was almost no effect on the primary customer ordering characteristics. With this information, it was concluded that transformation is contributes to increased supply effectiveness.

Subproblem 2

The second subproblem was to establish the correlation of the supply effectiveness indicators of requisition backorders and CWT to the ordering characteristics of average order quantity and requisition priority designators. Hypothesis 2 proposed that ordering behavior is positively correlated to supply effectiveness. The tested subparts were:

H2a: The average customer order quantity is positively correlated to the quantity of requisition backorders at their supporting warehouse.

H2b: The percentage of high priority designators (PD 02) assigned to requisitions is positively correlated to the quantity of requisition backorders at the customer's supporting warehouse.

H2c: The average customer order quantity is positively correlated to CWT.

H2d: The percentage of high priority designators (PD 02) assigned to requisitions is positively correlated to CWT.

Hypothesis 2 Results and Analysis

Utilizing a Pearson Correlation Matrix to calculate the relationships at a 95% level yielded no correlation for any of the subparts. The closest relationship was Average Order Quantity to Quantity of Requisition Backorders with a -0.147 correlation, but with a p-value of 0.054 it was statistically insignificant. The full results are presented in Table 4.

These results show that based on the research sample there was no correlation between the ordering characteristics of average order quantity and priority level and the supply effectiveness characteristics of CWT and requisition backorders in the following

period. This result is worth noting because it is counter to traditional wisdom on supply chain management, which teaches that these are primary drivers of ordering behavior.

Table 4. Correlation of Ordering Characteristics to Supply Indicators

	N	Average CWT	Backorders Over 30 Days	
% High Priority	192	0.000	-0.020	Pearson Correlation
		0.997	0.790	Significance*
Average Order Quantity	192	0.105	-0.147	Pearson Correlation
		0.170	0.054	Significance*

* Result is significant if ≤0.05

Subproblem 3

The third subproblem was to account for other sources of variance in the results. This subproblem utilized two hypotheses to serve as filters for ordering behavior.

Hypothesis 3 Results and Analysis

Hypothesis 3 predicted that the number of requisitions submitted by a customer is correlated to their deployment status. This hypothesis was based on the belief that units will consume more in a deployed versus garrison environment. Analysis was conducted using two t-tests: one compared garrison Class II with Iraq Class II requests and the second made the same comparison but with Class IX. For these tests, the unit was not relevant, so the data was pooled to provide a larger sample. The results showed that there was no significant difference between garrison and Iraq quantities of requisitions at a 95% confidence for either Class II ($p = 0.278$) or Class IX ($p = 0.941$). Table 5 shows the full results.

Table 5. Comparison of Average Number of Requisitions

Test #	Unit/Location	Supply Class	N	Mean	Std Dev	SE Mean	Difference Estimate	95% CI for Difference Lower	95% CI for Difference Upper	Significance Level *
	All Garrison	II	40	327	373	59				
1	All Iraq	II	52	404	281	39	-77.15	-217.98	63.68	0.2780
	All Garrison	IX	40	1256	1010	160				
2	All Iraq	IX	52	1243	486	67	12.82	-335.09	360.74	0.9410

* Result is significant if =0.05

The results show that units are submitting the same number of requisitions in Iraq as they do in garrison. Based on this result, the number of requisitions is not affecting the overall pipeline and CWT.

Hypothesis 4 Results and Analysis

Hypothesis 4 predicted that the allocation of priority designators is proportional to the number of customer requisitions. This was based on the belief that as numbers of requisitions fluctuate, the overall percentages of requisition priorities will remain static. Therefore the correlation coefficients should all be close to zero for this hypothesis to be validated. The results of the Pearson Correlation analysis yielded the following: PD 02 versus number of requisitions is -0.137, PD 05 versus number of requisitions is 0.082, and PD 12 versus the number of requisitions is 0.125. These results validated that the percentages of each priority designator do not fluctuate with the number of requisitions.

A second step in analyzing the allocation of priority designators was to compare the percentages of PD 02 requisitions between garrison and Iraq. Two t-tests were used to compare both units in garrison and Iraq for Class II and both units in garrison and Iraq for Class IX. These tests were chosen to match with the average number of requisitions comparisons used in Hypothesis 3. The results were that there is a significant increase in the percentages of PD 02 requisitions for both supply classes between garrison and Iraq. The estimated differences were -.19 ($p = 0.005$) for Class II and -.21 ($p = 0.000$) for Class IX. It is important to note that this data was calculated using percentages; therefore the

scale is 0 to 1. Converted to actual percentages, the increases are 19% and 21% respectively. Table 6 presents the full results.

Table 6. Comparison of Percentage High Priority Requisitions

Test #	Unit/Location	Supply Class	N	Mean	Std Dev	SE Mean	Difference Estimate	95% CI for Difference Lower	95% CI for Difference Upper	Significance Level*
	All Garrison	II	40	0.412	0.346	0.055				
1	All Iraq	II	52	0.601	0.268	0.037	-0.19	-0.32	-0.05	0.0050
	All Garrison	IX	40	0.373	0.211	0.033				
2	All Iraq	IX	52	0.587	0.16	0.022	-0.21	-0.29	-0.13	0.0000

* Result is significant if ≤0.05

Additional Tests for CWT

Due to the lack of a difference in the number of requisitions between garrison and Iraq and the high increases in use of PD 02, farther analysis was warranted. A quick t-test comparing the CWT for all garrison requisition periods (N = 84, Mean = 28.35, STD Dev = 14.61) to all Iraq requisition periods (N = 108, Mean = 29.38, SD = 16.33) yielded the result of no significant difference with a p-value of .6484. This result also validated the results for Hypothesis 2 which found no correlation between CWT and the percent of requisitions assigned PD 02.

Summary of Results and Analysis

This chapter presented the results of the data analysis. Hypothesis 1 found that supply effectiveness is improving with transformation, specifically through reduced average CWT and CWT variance, which answers the first subproblem. The second subproblem was answered when the correlation analysis showed no significant correlation between the variables. Subproblem 3 yielded some interesting results through the testing of the third and fourth hypotheses. The first is that the average number of requisitions in Iraq and garrison are statistically equal. The second is that priority designators remain allocated along the same percentages based on the total number of

requisitions for a period. However, this result does not match the comparison of the percentages of high priority requests between garrison and Iraq. That test showed a significant difference in the percentages of high priority requisitions. A final check of the data showed that there is no difference in CWT between Iraq and garrison.

V. Conclusion

This research yielded a variety of results, from the expected to the unexpected. This chapter seeks to provide the researcher's interpretation of the results, provide areas for future research, and reiterate the importance of this type of study.

Researcher Interpretation

This thesis began with the purpose of determining the effect of Army Transformation on supply effectiveness for BCT level units and attempting to identify the effects of the supply effectiveness on customer ordering behavior in terms of the overuse of high priority designators and average order quantities with the intent of providing an in-process review of the current status of logistics transformation. Answering this problem involved analyzing three separate subproblems. The results in some areas were expected and in others there were surprises.

Subproblem 1

Subproblem 1 looked at the effect of Army transformation on the supply effectiveness characteristics of CWT and requisition backorders. The test results showed clearly that CWT is lower and has lower variance in the transformed BCT. This was expected due to the removal of management layers at the Division level which allows a BCT warehouse to order directly through the higher supply echelons. The test results also showed that the number of requisition backorders was significantly higher in a transformed BCT. These seemingly opposite results were reconciled with the fact that the backorder quantities were not driving higher order quantities or assignment of more high priority designators to requisitions.

It is important to note that the backorder quantities are not always a bad result. Modular BCTs are designed for more agility which requires a lighter load carried with in the organization. This reduction in load includes reducing what is stocked in that BCT's warehouse. Obviously with a reduced stockage list, the number of backorders will increase. Customers can plan for the potential lead times for requisitions, provided that CWT variance is steady. An additional mitigating factor is the overall reduction in CWT achieved in the transformed BCT.

Based on this, it is apparent that overall supply effectiveness is improving with the transformed BCT. This shows that some of the steps taken so far in logistics transformation are working well.

Subproblem 2

The second subproblem attempted to establish the correlation of the supply effectiveness indicators of requisition backorders and CWT to the ordering characteristics of average order quantity and requisition priority designators. The results for this subproblem were simple, there was no correlation based on the sample used for this study. These characteristics do have relevance in the civilian world, but in the world of the U.S. Army there is not a correlation. This result is not discouraging, in that it points out the fact that more research is needed into the topic in order to address the factors that cause over-ordering and misuse of priority designators.

Subproblem 3

The third subproblem sought to account for other sources of variance in the results. Part one of the subproblem analyzed the differences in the numbers of requisitions between garrison and Iraq. The result was surprising in that the difference in

the quantities of requisitions is insignificant. This shows that unexpected numbers of requisitions are not causing a strain on the logistics framework.

The second part of the subproblem served to analyze whether or not the percentages of requisitions for each of the three priority designators remained the same based on the number of requisitions. This was found to hold true. Another surprising result was that the percentage of high priority requisitions increased by 19 percentage points for Class II and 21 percentage points for Class IX when the comparison was made between garrison and Iraq requisitions. A follow-on t-test revealed that the average CWT was not significantly different between Iraq and garrison.

Thoughts on High Priority

This begs the question of why the large increase in high priority requisitions; the short answer is because they can order high priority. A longer, more involved answer requires an understanding of the sense of urgency involved in the Iraq Theater of Operations. This researcher believes that the same urge that causes people to rush out before a hurricane or severe weather and buy everything they see in the store, also effects troops in Iraq. There is a great worry that they will not have something they need. From personal experience as a commander in Iraq, this problem is understandable. This researcher frequently sought to order an item as many ways as possible just in case the unit needed it.

This researcher's first exposure to this phenomenon was as a Second Lieutenant. Serving as the logistics officer operating a base camp for units training for Bosnia, one of the many illustrious duties was to ensure there was enough toilet paper. The Non-Commissioned Officer working for me would dutifully check the latrines and replace

missing rolls. He would constantly fret over the amounts being consumed. After addressing this issue to the Major that I worked for, he told me to fill the bathroom windows with rolls of toilet paper. In response to my look of confusion, he explained that soldiers always worry that critical items will not be available when they really need them. This is most obvious with toilet paper. Due to fears of shortages, the average soldier's first task is to take a roll of toilet paper from the latrine. The next soldier sees a roll missing and thinks there is a shortage, so he takes one too. This cycle continues until everyone has their own roll and they begin to consume what is actually in the latrine. By filling the windows with rolls, the perception of a shortage is alleviated and less toilet paper is required overall.

This analogy applies to every item of supply in the inventory. Despite the fact that CWT is lower and less variant and the overall supply system is more responsive, soldiers do not trust what they do not see or understand. Understanding the drivers of high priority requisitions and addressing potential overuse requires education of logisticians and maneuver commanders. High priority requisitions are a drain on the resources of the supply chain and with over 50% being high PD02, these requisitions become average priority by default. This results in odd circumstances where lower priority requisitions arrive faster on a ship, than a high priority requisition coming by air.

Areas for Further Research

This research shows the need for several avenues for additional research. The first suggestion is a similar analysis broken down by actual stock numbers. This would allow for identification of the actual items that are causing any discrepancies, as well as validate the aggregate results presented here. A second area for research is a behavioral

type study on the factors that cause customers to order the way they do. This has been accomplished in the civilian sector, but the military is unique in that there is no profit incentive. The third recommendation for research is a multiple regression analysis to control for other variables and autocorrelation of the data, as well as attempt to infer causality. A final area for research is to extend the study back in time and look at the characteristics over a longer period to identify any long-term trends that might serve to add to the research.

Why These Studies are Important

Understanding the results of the changes and being able to quantify improvements is critical in educating customers on the supply system. Quantification of ideas also helps erase the old "common-sense" type beliefs and fill them with grounded reality. If one can not quantify a problem and present quantifiable results, the problem can not be solved without the intervention of extreme luck and a great deal of hope. It is known throughout the Army that "hope is not a method," therefore it should not serve as a method for addressing logistical shortfalls and problems.

Appendix A. Data Tables

This appendix provides a listing of the periods used for calculations and a sample of the data table.

Table 7. Periods for Analysis

	Unit 1 Garrison	Unit 1 Iraq	Unit 2 Garrison	Unit 2 Iraq
1	6/12/2005	6/5/2006	6/12/2005	5/8/2006
2	7/11/2005	6/12/2006	7/11/2005	5/15/2006
3	7/17/2005	6/19/2006	7/17/2005	5/22/2006
4	7/24/2005	6/26/2006	7/24/2005	5/31/2006
5	7/31/2005	7/3/2006	7/31/2005	6/5/2006
6	8/7/2005	7/10/2006	8/7/2005	6/12/2006
7	8/14/2005	7/17/2006	8/14/2005	6/19/2006
8	8/21/2005	7/24/2006	8/21/2005	6/26/2006
9	8/28/2005	7/31/2006	8/28/2005	7/3/2006
10	9/4/2005	8/7/2006	9/4/2005	7/10/2006
11	9/11/2005	8/13/2006	9/11/2005	7/17/2006
12	9/18/2005	8/22/2006	9/18/2005	7/24/2006
13	9/25/2005	8/27/2006	9/25/2005	7/31/2006
14	10/2/2005	9/3/2006	10/2/2005	8/7/2006
15	10/10/2005	9/10/2006	10/10/2005	8/13/2006
16	10/16/2005	9/17/2006	10/16/2005	8/22/2006
17	10/23/2005	9/24/2006	10/23/2005	8/27/2006
18	10/30/2005	10/1/2006	10/30/2005	9/3/2006
19	11/6/2005	10/8/2006		9/10/2006
20	11/13/2005	10/15/2006		9/17/2006
21	11/21/2005	10/22/2006		9/24/2006
22	11/27/2005	10/29/2006		10/1/2006
23		11/5/2006		10/8/2006
24		11/12/2006		10/15/2006
25		11/19/2006		10/22/2006
26		11/26/2006		10/29/2006

Table 8. Sample Data Table

Unit 1 Garrison										
	Class II									
Period	AVE CWT	CWT VAR	Backorder >30 days	AVE AGE	2	5	12	TOT	AVE ORDER	VAR
6/12/2005	49.79	6165.41	189	34.30	151	1398	368	1917	6.24	421.45
7/11/2005	33.71	1796.45	244	36.32	7	516	465	988	4.91	268.60
7/17/2005	27.43	1206.02	258	43.02	3	24	330	357	12.54	2175.87
7/24/2005	21.98	839.18	240	34.23	1	114	93	208	12.97	310.68
7/31/2005	24.19	880.98	302	41.03	0	0	1	1	1.00	0.00
8/7/2005	40.03	827.57	231	36.42	0	0	0	0	0.00	0.00
8/14/2005	43.86	1601.68	207	39.68	88	9	267	364	3.51	123.61
8/21/2005	51.72	2089.78	267	35.66	0	9	58	67	18.55	581.28
8/28/2005	45.81	1242.74	225	38.61	18	148	77	243	12.12	1362.98
9/4/2005	63.67	3911.26	256	43.69	4	39	111	154	5.19	220.64
9/11/2005	70.27	6324.31	244	48.99	72	41	75	188	12.15	177.56
9/18/2005	35.78	1865.06	233	57.69	59	72	67	198	13.28	645.18
9/25/2005	39.51	6120.13	293	58.22	175	60	75	310	15.84	1029.43
10/2/2005	31.38	2524.24	228	56.40	8	4	55	67	8.39	49.15
10/10/2005	35.67	1954.16	218	58.07	27	70	0	97	10.89	281.93
10/16/2005	45.56	3912.88	220	64.77	194	62	91	347	11.63	306.90
10/23/2005	24.04	928.39	214	69.37	284	125	485	894	9.43	445.17
10/30/2005	12.42	942.70	243	58.51	33	15	1	49	12.55	240.71
11/6/2005	20.47	1184.31	227	58.57	13	0	0	13	9.23	22.03
11/13/2005	20.63	813.38	214	68.58	8	107	34	149	10.62	245.10
11/21/2005	43.94	1414.89	247	79.88	4	15	0	19	51.47	17229.71
11/27/2005	39.00	667.36	279	91.20						

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These abbreviations are used in the citations throughout the text:

CASCOM: United States Army Combined Arms Support Command
TRADOC: United States Army Training and Doctrine Command
ADCS-G4: United States Army, Deputy Chief of Staff, G4

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Vita

Major Joseph M. Colacicco graduated in 1996 from Kansas State University in Manhattan, Kansas with Bachelor of Science degree in Political Science. He was commissioned in the Active Army with a Reserve Commission through Army ROTC.

Major Colacicco's first assignment was to the 123rd Main Support Battalion in the 1st Armored Division located in Dexheim, Germany. There he served as a Company Executive Officer, Class I and Water Platoon Leader, Class II/IV/VII Warehouse Accountable Officer, and Support Operations Supply and Services Officer.

After attending the Combined Logistics Captains Career Course in 2000, Major Colacicco was stationed at Fort Bragg, North Carolina. His initial assignment was as the Deputy G4, XVIII Airborne Corps Artillery. Following that assignment, Major Colacicco transferred to the 82nd Airborne Division in 2002. In the 82nd Airborne Division, Major Colacicco served as the Division Support Command Plans and Operations Officer and as the commander for Headquarters and Alpha Company, 782nd Main Support Battalion. While serving in the 82nd, he deployed to Operation Iraqi Freedom as both a staff officer and as a commander.

In August 2005, he entered the Graduate School of Engineering and Management, Air Force Institute of Technology. Upon graduation, he will be assigned to 1st Brigade, 25th Infantry Division located in Fort Wainwright, Alaska.

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14. ABSTRACT

The United States Army began a major force transformation in 2003, which required a significant shift in logistics support constructs. This thesis provides an in-process review of the effects of the current transformation efforts on supply effectiveness and attempts to determine factors that influence customer ordering behavior. Specifically, this thesis sought to answer three subproblems addressing the effect of transformation on supply effectiveness, the correlation of supply effectiveness metrics to customer ordering behavior, and identify other potential sources of variance in ordering behavior.

The subproblems were answered through an examination of the supply document histories of two Brigade Combat Teams during two six month periods, one in garrison and one in Iraq. The results indicate that force transformation is increasing overall supply effectiveness, but that there is no correlation between the variables of supply effectiveness and customer ordering behavior.

15. SUBJECT TERMS

Supply Chain Metrics, Customer Wait Time, Army transformation, Customer Ordering Behavior

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